

Logistics in 2025: *Consider It Done!*



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Disclaimer

2025 is a study designed to comply with a directive from the chief of staff of the Air Force to examine the concepts, capabilities, and technologies the United States will require to remain the dominant air and space force in the future. Presented on 17 June 1996, this report was produced in the Department of Defense school environment of academic freedom and in the interest of advancing concepts related to national defense. The views expressed in this report are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the United States government.

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Executive Summary

Accessibility replaces anxiety in 2025 logistics. Confident that logistics systems will generate what they need when they need it, commanders of aerospace forces in the year 2025 contemplate strategy and devote their energy to the battle. The overall goal of this logistics thinking team was to ensure that commanders of 2025 retain visibility and control of the resources required to support national security objectives of the United States.

This paper proposes a “system of systems”¹ to provide a commander total asset visibility and seamless integration from cradle to grave for all major systems and their components. Advanced logic built into these systems streamlines the four core logistics processes discussed.

Acquisition: Acquisition reform and protected access to automated systems allows machines to procure consumable and durable goods. Human intervention by empowered employees is required only when defined parameters are exceeded. Critical concepts and subsystems of this system are communications, artificial intelligence, miniaturization, and virtual reality.

Materiel Management: Increased reliability and maintainability, purchases directly from the manufacturer, and on-the-spot manufacturing reduces materiel management requirements. Advanced miniaturization, communication systems, and computer aided design and manufacturing, plus recycling concepts deliver requirements when needed.

Transportation: Airlift is the major constraint in meeting current deployment objectives. A reduced footprint eases the airlift requirement. Efficient engines requiring less fuel and miniaturization yield increased lift capacity. Undersea and spaceborne prepositioning, and linked communication systems facilitate expeditious transfer of goods.

Maintenance: An aging fleet challenges 2025 maintenance personnel. Improved reliability and maintainability reduce the overall maintenance requirement. Modular construction, interoperable parts, lean logistics, and improved diagnostic and visual repair instructions improve the repair process. On-the-spot manufacturing increases maintenance flexibility. Improved materials, communication systems, computer aided design and manufacturing techniques, virtual reality, and miniaturization concepts are critical to streamlined maintenance in 2025.

Alternatives adopted by today's leadership in acquisition, materiel management, transportation, and maintenance ensure that support is on target and that the 2025 commander is in charge of the mission.

Notes

¹Lt Gen Jay W. Kelley, "Brilliant Warrior" unpublished paper (Air University, Maxwell AFB, Ala., 1996), 5.

Chapter 1

Introduction

Logistics has been a concern for military commanders since the beginning of time. Any organization, be it military or civilian, consumes resources and requires replenishment to accomplish its mission. Since merely wishing for supplies and support does not work, a formal logistics infrastructure is necessary to ensure support for any mission.

In 2025, as today, aerospace commanders may be asked to perform missions ranging from humanitarian support to total war. This paper proposes a logistics structure that includes a powerful new system capable of seamlessly integrating all logistics functions. This system would provide total asset visibility throughout the logistics process by linking all functions under one automated, “intelligent” system.

A highly sophisticated system that incorporates artificial intelligence, connectivity of automated systems, and hardened communications capabilities, it would introduce a logistics “system of systems” known as the battlespace responsive agile integrated network (BRAIN). This system would enable the logistician to efficiently and effectively manage assets to support the military commander.

This study discusses new technologies to shorten the logistics tail and reduce its footprint. By using highly reliable and miniaturized parts, we could reduce the amount of materiel that must be warehoused to support tomorrow's force. Additionally, this paper recommends employment of manufacturing techniques using lasers and advanced materials to manufacture on the spot at maintenance facilities and in the battlespace. Such repair reduces the amount of material to be transported. In the future, we expect self-assessing "smart parts" that automatically interface with the system to replenish themselves. Such replenishment would reduce the time and efforts required of maintenance and supply personnel.

In an increasingly austere environment, it is imperative that we get the most bang for every buck. BRAIN would enable the logistician to assure the commander to "consider it done" no matter how large or small the requirement may be.

Chapter 2

Required Capabilities

Regardless of events in the future, the key to air and space logistics capability is to transition from a primarily push (to the user) to a predominantly pull (at the user's demand) system. The balance between maintaining mission-essential materials for aerospace commanders and the high cost of storing excess material will not change. The logistics mission of getting the *right thing* to the *right place* at the *right time* and the *right cost* is a bulwark of military effectiveness.

Pull logistics, pressured by a cost-conscious public, will move depot operations to significantly smaller, decentralized facilities. Once instituted, pull logistics will require commanders to make a major paradigm shift. They will need to trust the newer system and decrease their reliance on stockpiling noncritical items.

Operators with pocket computers will load part specifications into computer aided design (CAD) software; miniature, portable machines with computer aided manufacturing (CAM) capability will allow operators to manufacture items at or near the point of need.¹ Microscopic, multipurpose snap-out chips and diminutive motherboards can be carried in wallet-sized pouches for on-site repairs. In addition to CAD capability, virtual reality systems will provide pictorial, oral, and written installation and repair instructions.

Immediate communication links with industry worldwide combined with on-line credit will become standard operating procedure. As global markets develop, the interests of Congress will shift to faster, better, and cheaper methods of promoting competition. Out of necessity, the Federal Acquisition Regulation (FAR) will be streamlined. Rules place acquisition authority in the hands of a few will be changed to empower a multitude of users to acquire necessities with minimum bureaucracy. Operators will be empowered to deal directly with manufacturers for items that are neither in stock nor adaptable to on-the-spot manufacturing. Factory-direct orders will substantially decrease the requirement for storage and distribution facilities and quick access to goods will allow a significantly reduced inventory that is collocated with the operator. The commander will have access to all information and will be able to request information on materiel availability or status in any form.

One of today's major problems is the lack of interoperability between computer systems. In 2025, multiple aerospace computer systems must interface with each other. Additionally, it is critical that those network links are extended to other services, foreign military units, and industry throughout the world.

Demands for efficient uses of taxpayer funds will result in continuing cost comparison efforts. The historic trend toward increased contractor awards will not change. Therefore, much of the remaining maintenance, repair, transportation, and storage facilities will have been privatized. There is much dissent throughout the system regarding the balance between the need for maintaining an adequate industrial base and the necessity for ensuring sufficient organic capability for mobilization.

As decentralization becomes reality, the target sets change. No longer are logistics support facilities (organic or private) centers of gravity—they are small and dispersed. No longer are communication centers a center of gravity—each person has a personal small pocket computer/communication tool. No longer are communication transmitters a center of gravity—multiple communication transmitters provide alternative links in the event any one link or group of links is incapacitated. Although we have reduced our centers of gravity, in 2025, everything is a target.

“We already know that older forms of warfare do not entirely disappear when newer ones arise.”² This also can be said of technological advances. As we reach to the future and find solutions to old problems, those problems will not go away entirely. The old issues will become increasingly blurred with new problems.

Since the current joint forces definition of logistics is, “the process of planning and executing the movement and sustainment of operating forces in the execution of a military strategy and operations,”³ that definition will not change in 2025.

To that end, we have identified four core capabilities: *acquisition*, *materiel management*, *transportation* and *maintenance*. The relationship of these core capabilities to the logistics goal, mission, and principles is illustrated in figure 2-1.



Figure 2-1. Logistics Goal, Mission, Core Competencies, and Principles

Although traditionally considered part of logistics, we have excluded base operating support activities and research and development. We also do not discuss the method of delivery, air, sea, ground, etc.). We assume an adequate combination of private and in-house delivery sources. We also assume that delivery systems and delivery ports will be adequately protected to ensure merchandise delivery in the year 2025.

Furthermore, we do not address communications systems. The scope of that subject is far too complex for this paper. Therefore, we assume that communication systems will be hardened and that alternate sources of delivery will be available. For example, if the BRAIN relies on satellites for communication, we assume that, should a satellite become inoperable, another satellite or a ground communication system will be available to ensure uninterrupted data transmission.

We are aware of the potential for logistics to become a joint (multiservice) agency, a combined (multinational) organization, or one owned and operated entirely by private industry. Whatever happens, the concepts we discuss could easily be adapted by any or all of these organizations.

Notes

¹Dr Craig M. Brandt et al., “Logistics 2025: Changing Environments, Technologies, and Processes” (Maxwell AFB Ala.: Draft paper for Air War College 2025 study, 1996), 28-29.

²Alvin and Heidi Toffler, *War and Anti-War* (New York: Warner Books, Inc., 1995), 97.

³Joint Publication (JP) 4-0, *Logistics*, 27 January 1995, I-1.

Chapter 3

System Description

All who study the government acquisition process agree acquisition reform is necessary. The acquisition system is being suffocated by the weight of the regulations designed to protect it. The reaction to several incidents of reported price gouging and cost overruns in the 1980s led to excessive regulatory oversight and control.

Acquisition

In the 1990s, Congress began adjusting the proverbial pendulum by enacting comprehensive legislation to streamline the military acquisition process. Leading the storm of reformation, Darlene Druyan, assistant secretary of the Air Force (acquisition), sparked change in the acquisition community when she issued eight lightning bolt initiatives on 31 May 1995. The initiatives called for bold and sweeping changes in how the Air Force runs its acquisition program.

While these “lightning bolts” shake the very earth on which the acquisition community stands, Druyan acknowledges this is just the *first step* in a series of required reforms. “People in the work force really want to do the right thing,” she says, “we just

need to give them guidance and council [sic]—we need to let them know it’s OK to remake their own roles in our acquisition system.”¹ It is essential that the government further automate the acquisition process and empower the military service user to deal directly with the supplier more frequently. The inflexible system currently in place is bureaucratic, redundant, and unresponsive to the needs of those charged with defending the nation. Development cycle comparison provides a good example.

Figure 3-1 shows that the time required to purchase major weapon systems ranges from four to 15 years.

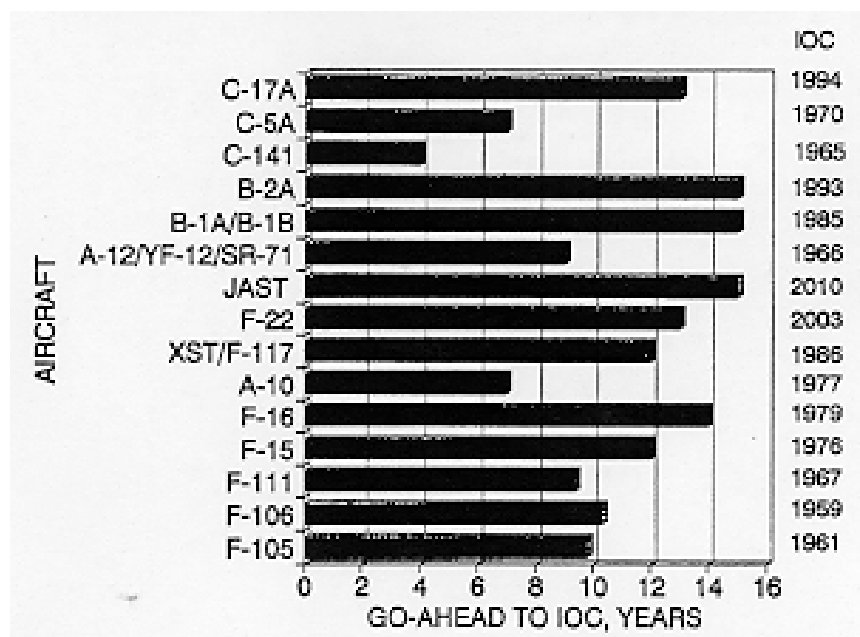


Figure 3-1. USAF Aircraft Development Cycles²

With technology development doubling every year, acquisition personnel often end up purchasing outdated equipment before it leaves the drawing board. The cost of

modifications made between the time of approval and receipt of the product creates delay, contributes to user anxiety, and costs millions of dollars.

On a much smaller and more understandable scale, the time required from “identification of need” to “satisfaction” is keeping us a generation behind. For example, ordering a software package can take five to seven years. This is inefficient and puts our government in a position of always being several steps behind industry. As technology progresses, this unacceptable lead time will result in a quantum governmental technology lag. To survive, the aerospace forces must assume a posture of industrial fusion rather than lagging separation. If the United States government does not get in step and stay in step with industry, countries who assume a progressive posture will quickly outpace, outperform, and, if so motivated, decisively defeat the United States military forces. It is critical that the United States armed forces be seamlessly integrated with industry.

The ideal way to expedite the acquisition system and achieve seamlessness is to empower the user and provide those individuals with an automated system. The systems proposed herein would have sufficient safeguards to ensure that only the proper user has access to the system and has not exceeded procurement authority. Purchases not meeting the requester’s requirements would not be automatically dismissed, but would flow to a higher automated or human review.

To avoid excessive training costs, the automated system must be simple and easy to use. However, the software would by necessity be complex. The “user/buyer” will not necessarily be a human being, it would be an inanimate device such as a maintenance microchip embedded in a weapon system or part. The following section describes how

BRAIN, our concept of a fully automated system, would streamline the acquisition process.

Microchip Purchases (Existing Stock)

The concept of a chip initiating a purchase to replenish stock presents a revolutionary opportunity for enhancing the acquisition process. “Machines need to talk easily to one another in order to better serve people.”³ For example, a microchip embedded in a hydraulic pump on an aircraft determines that the pump is eroding and will require replacement within five weeks. This microchip would transmit through a communication system, such as a satellite, the need to replace the pump. The requirement would enter “Otto” Auditor, the gatekeeper of the system. Otto would automatically query other systems to determine if a bona fide purchase requirement exists.

First, Otto contacts “Red E. Ness.” Red addresses the requirement from a national strategy perspective. Is the jet on which this pump is located going to be in the inventory when the replacement part is required? What is the importance of this jet in the prioritization list? If the requirement passes the need verification, Red sends Otto a message to proceed. Otto simultaneously contacts the other resource systems, “Budge-It,” “Man-Per,” and “Add-R-Quit Space.”

Budge-It assesses the unit’s budget and determines funding availability at the time of need. This system further makes decisions and performs calculations associated with the purchase. For example, Budge-It may determine the unit does not have the appropriate category of funds available to complete a transaction. It may then reallocate money from one category to another to allow the purchase.

Man-Per addresses the need for someone to perform the work. Are the right skills available in the appropriate place at the time the pump is scheduled for replacement? Man-Per contacts all associated support systems to ensure that medical support is available if someone is hurt while replacing the pump, that a fire station can support an emergency, and so forth.

Add-r-Quit Space checks to see if the appropriate repair facility is available at the right location when the pump needs replacement. If all systems are go, Otto contacts Virt-U-Log who scans the globe to determine if the part is currently available. If this is a high priority aircraft, a pump may be diverted from another repair site to replace this pump. Is the system at the right place at the appropriate time? If not, the request would return to Otto Auditor. Otto would perform a series of “decisions.” For example, is this a normal replacement? If not, the system might “decide” to refer the request to a human maintenance checker who would determine whether this required further investigation. If not, the maintenance checker would electronically coordinate and refer the request back to Otto.

Once the request has been validated, the Budge-It system would then allocate funds for the purchase. Having coordinated, electronically, Budge-It would send the request back to Otto. Otto would then execute many decisions to ensure the full coordination of all concerned functions, processes, or departments. These decisions are processed in milliseconds, with corrections and reviews made quickly. Human interface would be required only when built-in systems signaled problems requiring intervention.⁴ The end point for complications not remedied automatically would always be a human. This final human intervention would ensure that nonstandard requests would not be tossed into a

computer trash can. Figure 3-2 graphically depicts the interactions of the future logistics systems.

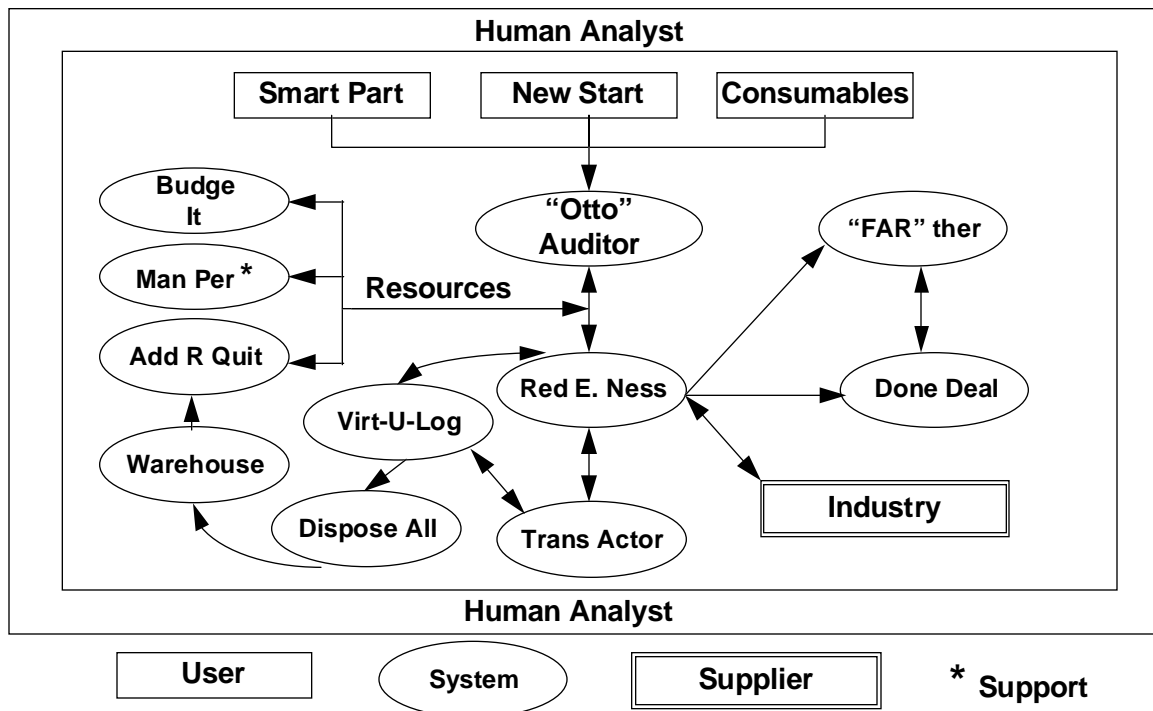


Figure 3-2 Battlespace Responsive Agile Integrated Network (BRAIN)

Upon completing its audit process, Otto would interface with a final “Smart Parts” system. Smart Parts would determine if the requested part fulfills the need. For example, it will determine if the pump fits the specific C-17 that ordered it. After ensuring that the part to be ordered meets the requirements, the system will identify a supplier and determine if that supplier proposes the best value. After SmartParts identifies an appropriate vendor and determines whether that vendor is able to provide the part at the right time, it orders the part.

SmartParts would then interface with “Trans-Actor.” Trans-Actor would arrange to have the part delivered to the right place at the right time. It would track the item from

time of receipt to time of delivery. Depending on part criticality, the details of tracking may vary. For example, for highly critical items, the system would know from minute to minute exactly where the item was. However, for less important items, Trans-Actor would provide visibility only when the part changed hands. Delivery may either be by organic or private sources. It would “correspond” with the aircraft to ensure that it was going to the designated repair site on the scheduled day of repair. In the event the repair site or schedule changes, Trans-Actor will reroute the part to a different location or alter the delivery date accordingly.

The casual observer can quickly see that the key to success is automated, integrated systems. Due to the global nature of transactions tomorrow, the systems will require international integration. Provisions for helping less automated, yet otherwise qualified, suppliers are necessary for the overall success of the bidding process. An on-line home page, accessible to anyone, would be required to ensure that small businesses and small countries with high-quality, low-cost items could compete in the system.

Human Generated Purchases

Authority verification for microchip purchases could be embedded in the microchip. However, the verification for human-generated purchases would be more complex and would require technology which is not currently used in personal computers. Computers could be equipped with biologically sensitive computer eyeball “printing,” a process that is similar to fingerprinting. Humans have distinctive, one-of-a-kind patterns on their eyeballs, just as they have unique fingerprints. Computers with eyeball printing capability could verify that the purchaser is who he claims to be. A “face recognition” verification

system would provide a second check when a dual check system is required. This face recognition system allows the computer to read the face and chemical makeup of individuals as they walk in the room.

Once verification is complete, the user would prepare the order. This information would be transmitted to Otto to ensure that, just as with the microchip, the individual is a qualified person who has the authority to transact this purchase request.

New Acquisition Purchases

The concept of integrating all functions is as important as the process of buying new weapon systems. As the acquisition process evolves from oversight to insight, a mental shift to define what is required rather than how to perform must occur. No longer will hordes of government engineers review and revise contractor plans. The scenario that follows demonstrates the potential magnitude of the costs associated with today's oversight. A notional systems program office could directly employ an average of 165 employees over a 15-year period. Using an average of \$34,000 per employee, the salary costs over the 15-year period would exceed \$85M \$5.6M per year. This figure does not include employee benefits, support personnel, cost of travel, redesign, supplies, or equipment.

How, then can this be done? Rather than competing for project contracts every four or five years, contractors would have full authority to manufacture the item and maintain the system from cradle to grave. Rewards for timeliness, high performance, reliability, and maintainability would be built into the contract. Likewise, stiff sanctions involving

suitability for future contracts and monetary penalties would be imposed on those who fail to perform.

The bid solicitation process would be computerized. Before bids are released, all organizations concerned, such as maintenance, budget, manpower, personnel, and supply, would simultaneously review the computer generated bid. Coordination would be required within hours or days rather than weeks and months. Much of the review would take place electronically. Again, human interface is only required if problems arise that are beyond the problem-solving capability of the computer reviewer's artificial intelligence.

Submission of contractor bids would be required within days. For the less sophisticated bidder, training programs would be available. All information and specifications would be available electronically. Forms for bid submission would allow bidders to simply and easily fill in the blanks. Standardized bid forms would speed up evaluation after bid submission. BRAIN would recognize anomalies and they would be tagged for human intervention. Calculations will be automatically performed. The simplicity of the new bid system would streamline the workload and might increase competition.

Materiel Management

A primary consideration in the logistics system of the future will be that of increased reliability of replacement parts. Improvements in reliability maintainability, and deployability are indeed challenges to traditional logistics concepts.⁵ This dynamic is true regardless of the future threats that aerospace forces will face in the next 30 years. A

magnitude of increased reliability would result in a decreased need for parts in inventory, storage costs, time, and effort expended in testing for defective components and replacing critical parts. An example of this is cited in *New World Vistas*:

When a turbine disk is degraded by fatigue in the bore of the component the whole disk is replaced at a cost of \$40K. Considerable savings might be affected by the use of new materials with improved properties and production methods that are more reliable. Furthermore, changes in design to permit replacement of only the degraded part of the component may also lead to significant decreases in costs. In replacing F-16 damaged fuselage frames a new alloy, Al-Li alloys, will be used. These new alloys will be more reliable than the older alloys used originally. Also, these new alloys have lower densities and hence, result in weight savings which is an additional benefit.⁶

Greater reliability of equipment and parts would also result in greater ease of monitoring safety levels of stock.

Just-in-Time Logistics

The core competency of materiel management includes the functions of distribution, movement, storage, preservation, and disposal.⁷ Just-in-time logistics capitalizes on the distribution and movement functions by getting the right things to the end user exactly when needed or as close to that time as possible. The warehousing function is thereby greatly reduced and the process is made more economical.

The first technology to address the logistics processes relevant in 2025 is that of a just-in-time logistics system using a worldwide, satellite-based communication system. The use of broad-band frequency sharing on existing satellite constellations would make this feasible by eliminating the need for dedicated orbiting platforms. This concept is not new. The US currently leases commercial satellites to augment existing frequency capabilities.⁸

In 2025, critical weapon systems and their supporting components will communicate with a worldwide logistics system through the use of small integrated circuits.⁹ Transportation, rather than storage, will become paramount in delivering equipment and supplies on time to the correct end-user.¹⁰ Taken individually, the capability of each chip may not be great on a relative basis, but collectively these individual chips and the items they are attached to can be monitored for usable shelf life, current stock status, and location. Just-in-time logistics, coupled with the technology of parts that “communicate” with the logistics system, will significantly reduce the quantities of stock sitting on shelves awaiting issue.

These “smart packages” or replacement parts would “talk” to a new series of satellites and their corresponding ground communication collection stations. This constellation of satellites would be deployed in groups of four: a prime collector/communicator, a transmission-only slave, a constellation backup, and a countermeasures/self-defense platform. Satellite communications must be enhanced to support increases in bandwidth demands. This type of satellite-based logistics system would require more bandwidth sharing. This, along with other battlespace data requirements, will place greater demands upon the communications capability of future satellite systems. However, according to *New World Vistas*,

Current efforts in fiber networks and laser communications are examples of areas where spacecraft and ground operations will benefit from commercial advances. Data compression techniques provide virtual bandwidth expansion and help minimize uplink requirements. Also, protocol advances such as the demand assigned multiple access (DAMA) will further enhance the capability of communication networks supporting the space mission.¹¹

Perhaps the satellite bandwidth sharing mentioned above will be integrated with the 2025 combat support thinking team's concept of virtual integrated planning and execution resource system (VIPERS). This system allows the commander to quickly view and assess the battlespace and, therefore, plan the theater campaign with much more confidence. A fundamental component of VIPERS deals with responding to the commander's need for the proper types and amounts of supplies and equipment needed to execute the mission. VIPERS relies on a constellation of advanced communication satellites.¹² Corresponding ground stations needed to interpret this data would exist within theater at the headquarters for each service as well as at the unified commander in chief (CINC) command level.

An example of how this system would work is illustrated by a weapons platform discharging a precision guided munition. When the weapon is discharged from the platform, a computer chip on the weapon automatically and transmits a signal to BRAIN via satellite. Thus, this munition reports itself as employed and no longer available for use, and reports that a replacement may be needed in-theater. If the decision is to replace the asset and there are none on the shelf, the requirement will be referred to the acquisition process within BRAIN. If the unit has no funding or the system is unable to complete the transaction for other reasons, the request would be referred to a human analyst (fig. 3-2) for further consideration.

This concept can also be applied to various other consumable supplies to include foodstuffs, personnel-related items such as clothing, and degradable medical supplies. This type of robust capability will allow for more rapid response and logistics cycle times and, thus, better support for the combatant commander.

Smart Package Technology/Trans-Actor

A derivation of this concept can be applied as a “smart package.” Large containers or large parts such as aircraft engines could also be equipped with chips that sense the package’s or part’s environment or status.¹³ When the materiel in the container needs to be moved to the theater of operations, the Trans-Actor subsystem of BRAIN programs the chip not only for its correct final destination but also the optimal path for reaching the field and perhaps even the use to which the items are intended.

When the package or part deviates from its known path or use, or when there is an unacceptable change in the package’s contents, it would communicate this change to BRAIN through the above-mentioned satellite network. Before releasing its contents, this smart package would demand authentication from the customer and also tell the customer the status of its contents and availability for use. Likewise this data would be downlinked to the satellite network so that logistics headquarters would receive notice of the packages arrival.

An added dimension of Trans-Actor is the ability to have parts delivered to the right place at the right time. Trans-Actor would “correspond” with the delivering vehicle to ensure that it was going to the designated resupply or repair site at exactly the predesignated time. If a delivery conflict developed, this system would automatically reroute the part to a different location or alter the delivery date accordingly.

Building up the Foundation

The developing technologies for truly just-in-time logistics are here now. Our current system of GPS satellites (fig. 3-3), along with our current mobile satellite tracking station would have to be upgraded to the next generation of applicable software.

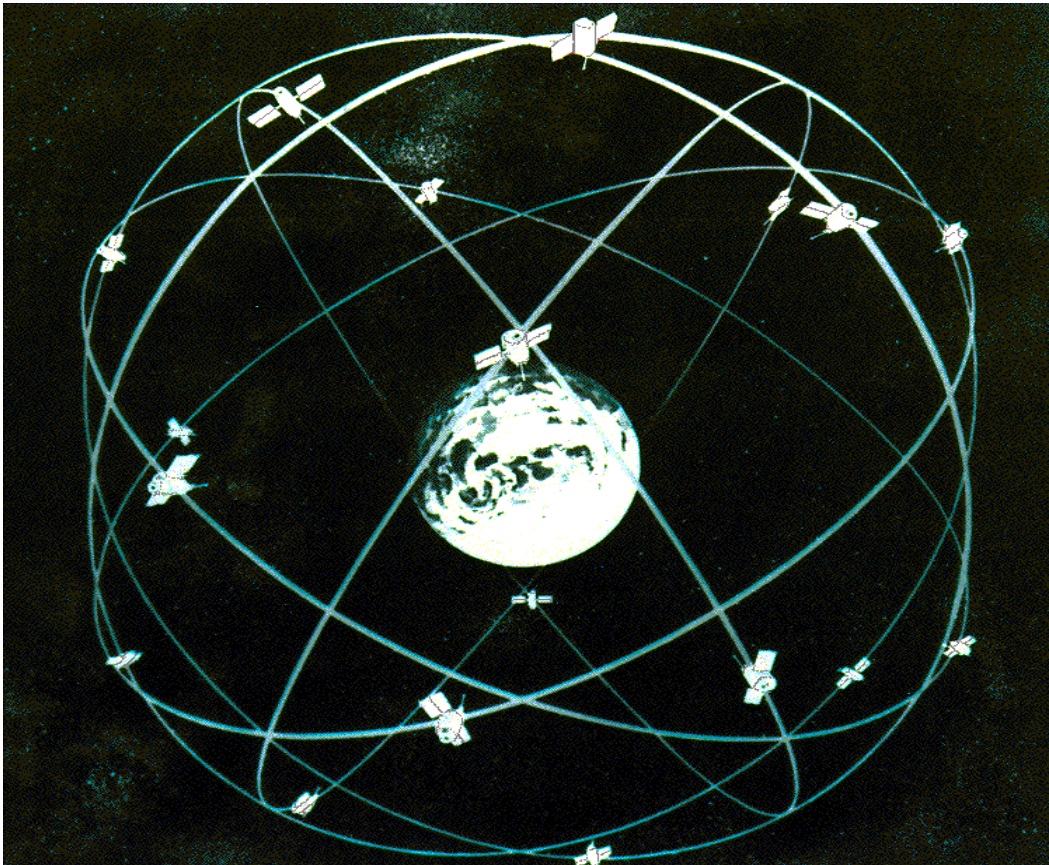


Figure 3-3. Global Positioning System Constellation

A system of “radio tags” that communicate with each other and to mobile and fixed terminals is being developed by a California company. These labels could be attached to containers and/or large pieces of equipment and instantly become inexpensive radio beacons. These beacons would continually transmit the simple tag number to a “smarter” tag actually within the container or piece of equipment. This internal tag would have the

manifest of the contents and directions for its shipping and disposition. These tags could then be attached to a variety of sensors to measure temperature, tampering, or leaks.

This system would be susceptible to certain countermeasures. The GPS receiver systems could be jammed or fed false data. Additionally, the receivers could theoretically be subject to “info wars” techniques such as the introduction of viruses into their software. The system would also be vulnerable if the enemy were able to decrypt the downlinked data at any point in the transmission process. Of course, direct attack of the satellite constellations by air-launched missiles or ground-based systems may be possible. Possible counter countermeasures to such a system involves hardening communication systems and making them more redundant. If one system fails, an alternate satellite constellation is activated to ensure seamless transmission of data.

This proposed just-in-time logistics system has an inherent advantage of being equally useful in both wartime and peace. The satellites are always in orbit and functional the vast majority of the time.

Each theater of operation would, in theory, have a logistics center along with the supporting satellite ground station. Logistics centers and the supporting ground satellite centers could be CONUS-based or afloat in prepositioned areas. The potential exists to use this logistics system on a daily basis to support global business. Our military would lease or use parts of the system only as needed by our national command authorities. In the future such sharing and “recycling” of scarce, expensive resources will help create a more seamless military-industrial complex relationship.¹⁴ This is vital, considering how unbearably expensive logistics systems have become.

Just-in-time logistics systems will have varying degrees of vulnerability in any level of conflict. To reduce this vulnerability and provide some measure of redundancy, the concept of assured delivery must be introduced. Assured delivery simply acts as a redundant subsystem of just-in-time to guarantee that emergency stockpiles of critical items are always available to the war-fighting CINC. These stockpiles are at critical secure points that could be used should the overall just-in-time system be interdicted or interrupted. Undersea prepositioning, as described later in this paper, is an example of one such protected critical point. While not totally invulnerable, assured delivery gives the CINC some measure of logistical insurance.¹⁵

Another potential problem with just-in-time logistics arises from the reliance on just one supplier or subcontractor to manufacture a needed part or subcomponent. A recent example of this happening was the March 1996 strike by a General Motors brake assembly plant in Dayton, Ohio. The shutdown idled a total of almost 167,000 workers and halted production in 26 of General Motors' 29 North American plants.¹⁶ To counter these types of production shutdowns, redundancy should be introduced into the manufacturing process by providing for multiple suppliers of key components whenever possible.

Reverse Logistics

The idea of environmentally correct warfare will undoubtedly be important in the future. One of the necessary components of materiel management will involve the proper disposal and/or recycling of a large number of the items used in the battlespace of the future. The materials used by the aerospace power of the future may be significantly

more toxic than those used today. If so, society will demand their proper disposal. Sherri Wasserman Goodman, under secretary for environmental security, stated to Congress in 1994 that, “at first notion a green weapon system may seem absurd, but in reality it is not. Those systems spend most of their lives in a peacetime role and often remain in the inventory for 30 years or more. During that time maintenance and refurbishment performed by contract and at our industrial depots use large quantities of hazardous materials and generate large quantities of waste.”¹⁷ This trend will certainly continue. The materials manager in the year 2025 must learn from the example of industry and also concurrently develop environmentally benign methods to dispose of outdated weapon systems and their infrastructures.

A maturing concept that will help in the reverse logistics process of the future is the life-cycle assessment (LCA). This concept displays an acceptance by manufacturers of their willingness to share responsibility for the environmental burden of a product from initial design to final disposal.¹⁸

Life-cycle assessment goes beyond mere superficial environmental improvements targeted at the disposal phase. This process is a snapshot in time of total system inputs and outputs involved with a weapon system, process, or related activity. Life-cycle assessment is expensive but is thought to be effective. It is composed of three separate but interrelated components: life-cycle inventory, life-cycle impact analysis, and life-cycle improvement analysis.¹⁹

The “pollutant universe” that LCA will attempt to deal with is shown below in figure 3-4.

DEFINING POLLUTION

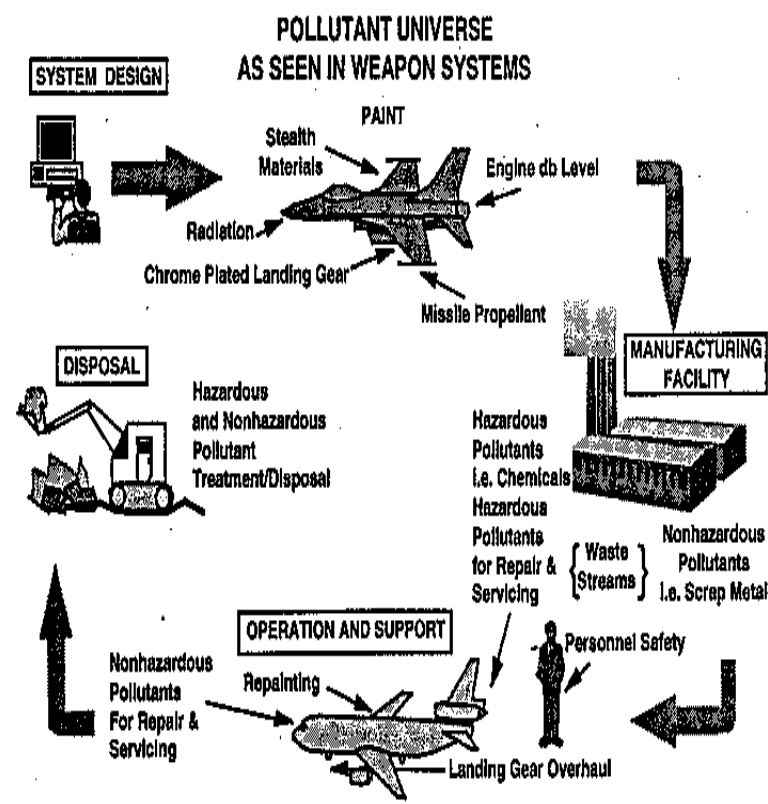


Figure 3-4. Pollutant Universe

Groundwork for environmentally sensitive systems of the future is being laid now. The Armstrong Laboratory, specifically the Logistics Research Division, is currently working on an Aerospace Generation Equipment (AGE) concept called “Green AGE.” Once developed, DOD users will have effective AGE equipment with reduced undesirable emissions.²⁰ Much of this type of “green” work by the Air Force will have far-reaching effects well into the next century.

Miniaturization

Making items smaller has distinct logistical advantages. Smaller items such as “micro-MREs” (meals ready to eat) and smaller, lighter munitions are cheaper and easier to store and transport.²¹ Such items would require a less complex logistics system and allow greater ease of transportation. In the future, transportation capability will always be a critical constraint.

Advancements in explosives development may soon allow for weapons with as much as ten times the destructive force of today’s weapons while weighing only ten percent as much as current weapons.²² The logistics trail of such smart munitions will certainly be smaller and less complex due to reduced handling requirements and much less space needed for transportation.

Micro-MREs are self-contained meals the size of a vitamin pill that contain all essential nutrition and calories to sustain a person for a 24-hour period (fig. 3-5).²³ This would obviously help in battlespace logistics with storage and shipping requirements as well as a lighter load for the individual soldier, sailor, marine, or airman. Advances in nutrition and food packaging should make this technology possible by 2025.

The National Aeronautics and Space Administration (NASA) is doing considerable research on foods for space flights, especially that intended for their extended-duration orbiter (EDO) missions.²⁴ As expected, weight and volume are critical factors for every piece of hardware placed onboard the shuttle orbiter. As a result, the weight allowed for food is limited to 3.8 pounds per person per day which also includes one pound of packaging material needed for each individual.²⁵

NASA's research to make foodstuffs more weight-and-volume efficient includes work on rehydratable items that use water made from the orbiter's fuel cell system, which produces electricity by combining hydrogen and oxygen. Ongoing work involves thermostabilized (using heat to destroy deleterious microorganisms and enzymes), intermediate moisture (foods containing 15-30 percent water) and irradiated foods to reduce the overall bulk of needed meals.²⁶ The logistician of the future will surely be able to capitalize on these concepts to feed the troops as well as to help reduce the overall logistics footprint.



Figure 3-5. Food Pill

The only countermeasure to the small smart bomb lies within the development of new, extremely strong shielding materials. There are no countermeasures to the micro-MRE except that they should probably not be used on a routine basis due to morale considerations.

Both of these technologies could be employed basically as they are today. The idea of miniaturization could be applied in both joint and combined environments in peace and during war. Also, both of these concepts could be easily used in the just-in-time logistics concept mentioned above. Fewer people would be needed to handle smaller and lighter equipment and/or supplies. Therefore, a simpler and smaller logistics system could be employed.

Virtual Materials Manager

Visualization technology for the logistician of the future will “permit human-centered aspects of system operation and maintenance to be simulated and fully verified before hardware is produced.”²⁷ The keys to this virtual world are digitization of product and supply data along with more low-cost computing power.

This technology will allow certain aspects of logistics to be modeled with much greater realism and larger consequence than ever before. An example might be the movement of military material through aerial ports that could be simulated graphically to identify bottlenecks, optimize warehouse space and resource utilization, and manage air and ground transportation functions. This modeling could also allow logisticians to have real time pictures of the status of critical cargo items in transit, port and depot operations, and airlifter/sealifter locations across the globe.

The benefits of the logistician of the future using visualization technology can be directly tied to logistics planning. The reduction of the weight/volume of logistics support needed for deployment will be a requirement in more than one alternative future indicated in the 2025 study. In the past, logistics support was a “push” phenomenon that

moved thousands of equipment/supply items toward an end user regardless of specified demand. This ensured a high degree of readiness at a very high cost. Logistics simulation based on virtual reality will help to develop a more efficient “pull” process that allows specific items to be dispatched and tracked separately, that is, just-in-time to be effective.²⁸

Transportation

Transportation plays a crucial role in our efforts to logistically facilitate a commander’s strategy rather than constrain it. Simply stated, transportation is the means by which we get things from *where they are at* to *where they’re needed*. Equally straightforward is the objective of any transportation system; getting things from where they were to where they’re needed *faster and cheaper-faster* because other events or processes are typically delayed until the arrival of the thing being transported and cheaper because of decreasing dollars available to support an increasingly transportation-dependent military. Three basic drivers of any transportation system are (1) how much material requires transportation, (2) how far the material needs to be transported, and (3) how fast a mode of transportation can deliver the material.

Our Feet Are Too Big

Current transportation requirements are based on a prerequisite for large amounts of personnel, equipment, and consumables in order to employ the military instrument of power. To the extent possible, this requirement, or dependence, should be reduced.

Regardless of how the future looks in 2025, it is safe to assume that we will benefit from reducing the amount of people, equipment, and consumables requiring transportation in order to exert our will.

Reductions in the weight associated with military presence, whether for warfighting or operations other than war, reduce our logistics footprint and hence the overall transportation time required. Essentially, reducing the transportation requirement allows existing transportation systems to achieve both the “faster” and “cheaper” objectives.

Actual methods of reducing the weight of the transportation requirement, or reducing the “ton” portion of a CINC’s ton-miles per day requirement, will not be discussed under this transportation section. Reducing the weight of the transportation requirement is only offered conceptually, to underscore the fact that multiple avenues for increasing the responsiveness of transportation exist.

Closer Is Quicker

To the extent the weight requiring transportation cannot be reduced, we can attempt to reduce the distance over which the weight must be transported. Reducing the “miles” variable in the ton-miles per day transportation metric reduces the time required to receive equipment and consumables in-theater. Concepts related to reducing the distance over which the weight must be transported are essentially variations of materiel prepositioning. Although primarily material management methods, the issues are addressed here because the deployment and recovery of prepositioned materiel are dependent upon transportation systems.

The first concept is undersea prepositioned materiel.²⁹ Vast amounts of materiel currently stored afloat prepositioning ships and prepositioned overseas in warehouses could be stored on the ocean floor off the coast of a region of potential use. The vulnerability of the stockpiled equipment to enemy attack would be reduced compared to current prepositioning as would the long-term costs of leasing ships and warehouses.

Deployment of the materiel to its underwater location would be done using self-propelled smart containers capable of guiding themselves to their final destination after being dropped from their transport system. The drop-off transport service could be provided by any conceivable mode: ship, aircraft, or lighter-than-air (LTA) craft. In any case, the actual drop-off would be conducted covertly to guard the location of the underwater prepo. Ships would be modified to deploy containers internally below the water line. Aircraft would deploy containers from low altitude or drop stealthy containers from high altitudes. Stealthy, heavy-lift, LTA craft could deploy containers and subsequently recover them for intratheater direct delivery under conditions of air superiority.³⁰ The containers themselves would become intermodal transportation systems capable of navigating to their underwater destination using onboard systems and controls. Upon activation for use, the underwater containers would maneuver to rendezvous with a recovery platform or transport themselves to a beach or port.

Another variation of propositioned materiel is the use of spaceborne modules containing light-weight, mission-essential items.³¹ Energy cells, which could serve as ammunition or fuel, would be stored and recharged in space using solar panels built into the container/reentry vehicle. Critical, miniaturized spare parts, medical supplies, and dehydrated food could be stored in space and arrive directly where needed. Within

minutes of request by the user, BRAIN's Otto Auditor and Trans-Actor systems would react. The containers would be intermodal with space transport systems such as the Titan IV system shown in figure 3-6. They would be capable of self-guidance and delivery to a precise location when called upon.

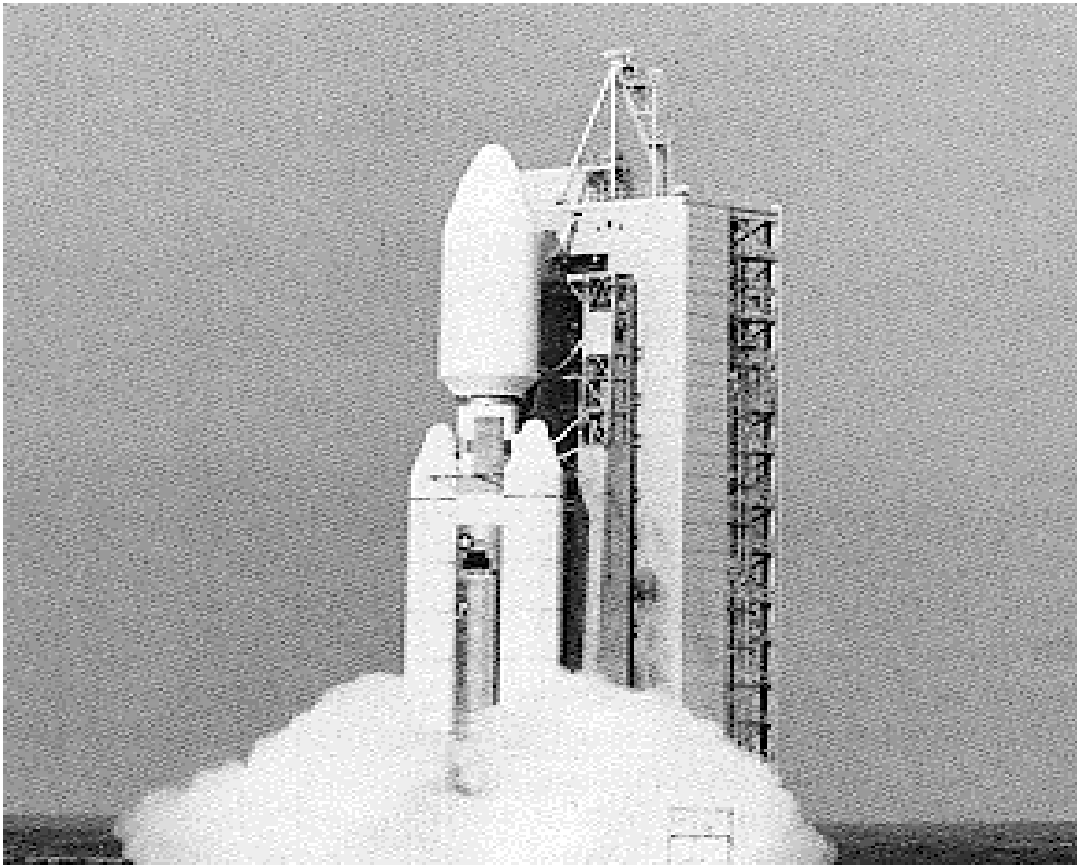


Figure 3-6. Titan IV Rocket and Payload—Spaceborne Prepo?

The space module could deliver its entire contents to one location or direct sub-deliveries, depending upon the request. Materials too heavy for transport into space could be manufactured in space from spaceborne resources or debris and stored in an orbit which minimizes transit time.³²

Think **Huge**

Beyond reductions in the weight of the materiel requiring transportation and reductions in the distance over which the materiel must be transported, the transportation system itself is called upon to move things faster and cheaper. With respect to transportation platforms, moving things faster calls for some combination of more platforms, larger payloads, and reduced transit times. Specific transportation concepts are not developed under the logistics section since this subject is covered by the air mobility thinking team. Additionally, the Trans-Actor system would be programmed to arrange the most efficient combination of transportation modes based upon the situation. Those transportation concepts that were submitted as part of the 2025 study and were considered relevant to logistics, are discussed in appendix A.

Maintenance

Considering the guidance contained in Joint Vision 2010, *America's Military: Shaping the Future*, and the current trends, depot-level maintenance will be privatized in the future. The Air Force supports an amendment to change current legislation (which requires that 60 percent of depot maintenance be performed in-house) to allow for more outsourcing. In 2025, most depot-level work will be performed by private contractors. Base-level or intermediate-level maintenance will remain within the service, with a renewed emphasis on ensuring that mission-essential systems are maintained in combat-ready condition.

Given the increasing costs of fielding new aircraft, extending the operational life of existing weapons platforms will result in retention of aircraft built during the later part of the twentieth century. For example, according to the *New World Vistas* report on materials for the twenty-first century, the C/KC-135, B-52, and C-130 are projected for use well beyond 2025 (table 1).³³ Maintenance of aircraft of this "vintage," coupled with the requirement to support new systems for air and space travel, offers unique challenges.

Table 1.

Fleet Life Extension

Aircraft Type	Number of Aircraft	Average Age	Projected Retirement
C/KC-135	638	33	2040
B-52	94	34	2030
C-5A	77	25	2021
C-141	248	29	2010
C-130 (20 years or older)	439	30	2030
F-15	940	12	2020
F-16	1727	7	2020

Challenges relating to an aging aircraft inventory include the replacement or repair of damaged components on the aging systems, countering the effects of the deterioration and corrosion process, and ensuring that the level of maintenance expertise is preserved. These challenges will be minimized through the use of innovative ways of improving reliability and maintainability of new and replacement parts. Additionally, improved

materials, smart systems, and methodology designed to provide the maintenance technician the most comprehensive and up-to-date database, will be essential.

Improved Reliability and Maintainability

Newly developed aircraft will embody more reliable and maintainable systems and equipment. Therefore, intermediate-level maintenance should decrease. As a result, life-cycle costs will become far more reasonable. Aircraft and weapons systems will require far less supply support for parts, fewer personnel for repairs, and less time out of service for maintenance.

Since first implemented in the mid-1990s, the Reliability and Maintainability (R&M) 2000 program has resulted in significant reductions in the cost of integrated logistics support. This program gave reliability and maintenance the same weight as cost, schedule, and performance requirements during new weapon acquisitions and modifications to existing systems.

Under incentive by contracts, vendors have offered more reliable systems and components. These contracts have already resulted in reductions in maintenance requirements for current systems. For example, as a result of modifications and upgrades under this program, the B-52 mission-capable rate went from 38 percent in the early 1980s to over 81 percent during Desert Storm.³⁴

Along with improved reliability, system designers must emphasize interoperability in parts and components to further reduce the logistics footprint. As new systems are fielded, composite material enhancements must be incorporated into maintenance on the aging systems to extend their usefulness.

Modular Design

The development of modular aircraft, coupled with highly reliable and easily maintained systems, will minimize logistics requirements and simplify maintenance needs. By capitalizing on modular propulsion and, avionics, and weapon-and flight-control systems, manufacturers will design aircraft that can be easily configured to meet specific missions—even within the battlespace.³⁵ By standardizing systems as much as possible, we will realize significant savings through reduced production line retooling.

Another promising concept for streamlining maintenance requirements is a proposed redesign of AGE using a modular methodology. The AGE would be designed with all common systems (air compressors, generators, and hydraulics) combined in the same unit. Systems would be designed as modules that could be quickly and easily removed and replaced, allowing for rapid repair or reconfiguration for differing aircraft. Two major benefits of this system are more commonality between bases and less equipment processing during mobility exercises.³⁶

Lean Logistics

"Lean logistics" is another current initiative that is contributing to an overall decrease in intermediate maintenance requirements this initiative will prove valuable through 2025. One of the essential premises of lean logistics encourages the use of *current* business practices which have proven successful in commercial application. For example, fostering closer partnerships with suppliers results in a smoother pipeline for parts and support. Today, a benefit of improved relationships has been the move away from maintaining large inventories of spare parts.

Successes in this area would influence aerospace repair facilities to cease reliance on mass production methods and to adopt simpler, more integrated production systems.³⁷ The aerospace forces can move away from the costly and redundant just-in-case ideology to the newer and more practical just-in-time philosophy. However, the concept of lean logistics does not preclude stocking a safety level of critical items necessary to ensure the crucial level of readiness required by the Armed Forces.

To fully realize the benefits of a truly lean logistics system, we need to develop both long-term business relationships with suppliers and a more robust capability to fabricate replacement parts internally. Employing CAD and computer-aided manufacturing (CAM) techniques along with the use of "intelligent" materials which are capable of adapting themselves for use will be critical to on-the-spot fabrication.

Locally Manufactured Parts

The use of CAD and CAM coupled with new and improved materials will allow intermediate maintenance facilities to reduce their dependence on the supply system for parts. A critical component of the acquisition process and subsequent Integrated Logistic Support provided by BRAIN is the requirement to acquire all data relating to specifications, materials, and processes associated with the manufacture of parts when they are initially acquired. This information is subsequently available to the technician through the Virtu-Log subsystem of BRAIN. Consequently, in 2025, each facility will have the maintenance history and drawings for each and every part.

Intelligent materials, both composite and plastic, will be used to fabricate parts. A working group headed by Charles Owen has created computer-generated representations

of uses for "nanoplastics." This material is based on the concept of theoretical fusion of the traditional field of plastics and that of nanotechnology. The field of nanotechnology is where microscopic machines and other objects are constructed atom-by-atom.

Computers the size of a blood cell would be contained within nonplastic material, giving objects enormous processing power ("intelligence"). Sensors and emitters would be constructed to absorb and transmit pressure, sound, and nearly the entire electromagnetic spectrum. These would provide nanoplastic materials with the ability to sense their surroundings and to respond with physical change or the transmission of sound, light, heat, or other emissions.³⁸

The *New World Vistas* white paper on materials provides another method of composite fabrication that involves the direct spray-up of molten metal droplets onto a final shape to provide rapid solidification.³⁹ Further research in these two areas may significantly enhance the ability of 2025 technicians to fabricate replacement parts themselves.

Robotics Technology

Automated, or robotic, systems should streamline maintenance functions. Today, a robot system called the automated aircraft rework system (AARS) is being used to remove several types of fasteners on F-15s at Warner Robins AFB. Designed and integrated by Mercer Engineering Research Center (MERC), this system locates, identifies, maps, and removes wing fasteners. After workers repair or replace wing panels, AARS drills holes and reinstalls the fasteners. This automated system can do in one day, what it used to take a team of technicians one week to accomplish.⁴⁰

A "machine vision system" locates, identifies, and sends data to a control computer. The computer stores a map of the wing. Using a form of artificial intelligence, the robot

decides whether to unfasten or drill a screw. A laser system keeps the tooling perpendicular to the wing. Given the success of this system, similar systems will be developed in the future to include routine functions such as changing tires, brakes, and lubrication. The cost of building new aircraft will be significantly affected by this new technology.

Neural Networks and Artificial Intelligence

A developing technology—neural networks—may provide a revolutionary capability for maintenance diagnostics that will significantly affect logistics support. Neural nets develop diagnostic strategies by learning from past experience with the system. Today, there is no system capable of accomplishing maintenance using this technology.⁴¹ However, in 2025, the maintenance technician will couple his or her own experience with that of a neural network diagnostic system to cut maintenance time and costs. Troubleshooting technicians will use programs that analyze the problem and the maintenance history of the equipment. These programs will then perform diagnostic tests and make maintenance recommendations to the repair technicians.

The system would assess parts availability and order whatever was needed to repair the system or component. Each aircraft or weapon system would have a record much the same as a medical chart. With each visit to the “hospital/maintenance facility,” any tests, diagnoses, repairs, or installations of new or reworked parts would be entered on this record. For each piece of equipment, the record would be available to any technician anywhere in the world or in space.

Another important area of maintenance at the intermediate and local level is that of processing engineering and maintenance changes to existing systems. Technicians need up-to-date information regarding processes, parts, and supply support. The information system supporting this process should to ensure immediate system response. Data changes must be made to all data bases—and data must be audited globally for accuracy and synchronization. Our neural network will integrate automated support tasks such as those described above.

Smart Parts

Another means of reducing the logistics footprint from maintenance requirements involves using information systems to analyze existing data to establish spare parts inventory levels. For example, by using chips in parts (making them “smart parts”), we could make each and every spare part a part of the information system.⁴² Chips could be used in key components of aircraft to tell us when they have reached a true point for maintenance needs.

Smart part aircraft would continuously run diagnostics upon themselves. These parts would have the ability to link into the BRAIN system to assess replacement availability in the event of pending failure. At any time, even during flight, when the part anticipates a problem or the end of its useful life, it would report itself as failing and would automatically “check” the system for replacement. When the system landed, the ground maintenance personnel would analyze the automated report to determine the health of the system. In the event of a failure or pending failure, the supply request would already have been generated and timely repair could be accomplished.

Simple measures, such as total stress or total cycles, would be more effective measures than today's which made use of airframe or engine hours. Other useful parameters are mean time between corrective maintenance actions, mean time to repair, mean requisition response time, and gross effectiveness. Proper analysis of these parameters could result in significant inventory-levels reductions.⁴³

Virtual Reality

Virtual reality (VR) will provide the means to make maintenance technicians capabilities *virtually* limitless. With the requirement to maintain aging aircraft as well as state-of-the-art systems both at home base and when deployed, the maintenance technician will require an encyclopedic level of knowledge. Not only will VR be a valuable training tool to initially train technicians; it will be a valuable tool on the battlespace when technician could be faced with problems they have never encountered before.⁴⁴ By using VR technology, we can make training realistic. It would be the next best thing to actual "hands-on" experience.

A virtual reality library that contains complete information for every system would be easily transported to the battlespace. This information would provide a visual 3-D picture, complete with audio guidance on every platform and system in use. This system would enable maintenance technicians to assess battle damage by comparing the damaged component or system to one in perfect working order. Because VR is interactive, the technician could query the system to learn how to repair or replace things. Virtual reality will enable every technician in the battlespace to effect repair on any system.

Interface with Combat Readiness Systems

The logistics system of the future will provide a direct link to the system that measures unit readiness. This system measures unit readiness in many categories and for different missions (see “Combat Readiness” white paper). When a system is down for maintenance, whether routine or emergency, the logistics database will provide the necessary information to the readiness system. The commander will be provided an estimated time for repair and notification of any supply support problems that may impact the process.

Notes

¹News From AFAR 1, no. 3 (June 1995 special): 1.

²USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century* (unpublished draft, the materials volume, 15 December 1995), 24.

³Nicholas Negroponte, *Being Digital* (New York: Vintage Books, 1996), 207.

⁴*Ibid.*, 93.

⁵Lt Col James C. Rainey, Air Force Logistics Management Agency, interview with authors, 7 February 1996.

⁶*New World Vistas*, (unpublished draft, the materials volume), 2.

⁷Rainey.

⁸EOS Technologies, Inc, for the Army Space Institute, 1990 “Space Support in Mid-Intensity Conflict,” in Maj Pat Battles, ed., *Theater Air Campaign Studies*, (Maxwell AFB, Ala.: Air Command and Staff College, 1995), 306.

⁹2025 Concept, No. 900672, “Integrated Logistical Sustainment,” 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

¹⁰Rainey.

¹¹*New World Vistas*, (unpublished draft, the space technology volume), 68.

¹²Lt Col Gregory Miller, et al, *The Virtual Integrated Planning and Execution System: The High Ground of 2025*, Project 2025 white paper, 21 March 1996.

¹³2025 Concept, No. 200019, “Smart Packages,” 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

¹⁴2025 Logistics Thinking Team Briefing to Scientific Advisory Board, 7 February 1996.

¹⁵Dr Paul F. McManamon, Air Force Scientific Advisory Board (Assessors), briefing to Air Force Scientific Advisory Board, 27 March 1996.

Notes

¹⁶Neal Templin, "GM Strike Hits Mexican Output as Talks on Settlement Resume" *Wall Street Journal*, 20 March 1996.

¹⁷*New World Vistas*, (unpublished draft, the materials volume), 38.

¹⁸*Ibid*, 44.

¹⁹*Ibid*, 46.

²⁰Logistics Research Division, Armstrong Laboratory, Wright-Patterson AFB, staff presentation document, March 1996.

²¹2025 Concept, No. 900510, "Micro MREs," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

²²2025 Concept, No. 900233, "The very small, very smart bomb," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

²³2025 Concept, No. 900510, "Micro MREs," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

²⁴"Food For Space Flight," NASA Facts, (Internet source), NASA home page, <http://shuttle.nasa.gov/sts-69/factshts/food/html>.

²⁵*Ibid*.

²⁶*Ibid*.

²⁷Notes, S&T Issue: Visualization Technology For Logistics, Mr. Bertram Creme, Armstrong Laboratory, Logistics Research Division, Wright-Patterson AFB, OH

²⁸*Ibid*.

²⁹2025 Concept, No. 900401, "Undersea Prepositioned Material," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

³⁰2025 Concept, No. 200038, "Super-Airship Military Transports," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996); 2025 Concept, No. 200076, "Very Large, Heavy Lift Transports," 2025 Concepts Database (Maxwell AFB Ala.: Air War college/2025, 1996)

³¹2025 Concept, No. 900265, "Space Storage Modules To Establish Space-sourced Air Drop Capability", 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

³²2025 Concept, No. 200225, "Spaced Based Manufacturing and Recycling System," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

³³*New World Vistas*, (unpublished draft, the materials volume), 29.

³⁴Lt Col Michael R. Van House, "A Proposal to Restructure the Logistics Group," *Air Force Journal of Logistics*, (Summer 1995), 32.

³⁵2025 Concept, No. 900380, "Modular Aircraft," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

³⁶2025 Concept, No. 900539, "Aerospace Ground Equipment (AGE) Redesign," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

Notes

³⁷I.K. Cohen et al, "Lean Logistics, A More Responsive, Robust, and Affordable System," *RAND Report DRR 630-AF*, (January 1994).

³⁸Kevin McGuinness, "NANOPLASTICS-How 'Intelligent' Materials May Change Our Homes" *The Futurist*, January-February 1995; 50.

³⁹*New World Vistas*, (unpublished draft, the materials volume), 65.

⁴⁰Staff Writer, "A Robot Wings It," *Mechanical Engineering*, (April 1995), 3.

⁴¹"Application of Artificial Neural Network (ANN) to Aircraft Diagnostics," (Internet source), AL/HRGO homepage, Worldwide Web.

⁴²2025 Concept, No. 900611, "Smart Parts," 2025 Concepts Database (Maxwell AFB, AL: Air War College/2025, 1996).

⁴³"Readiness Base Sparing Assessment," (Internet source), <http://www.nslc.fmso.navy.mil/rbs1.htm>.

⁴⁴Nicholas Negroponte, *Being Digital*, (New York: Vintage Books, 1996), 215.

Chapter 4

Concept of Operations

Our vision is of a logistics system of systems that provides total asset visibility yet is transparent to the regional commander in chief by facilitating rather than constraining strategy. This vision is best illustrated with a notional vignette.

Scenario

“How are my birds tonight, Sue?” The second shift of unmanned aerial vehicle (UAV) flyers were making their way into the control room and Maj Helms was preparing to take over Sue’s spot at the controls.

“Started with four, ended with four,” replied 1Lt Sue Sloan, the Air Force’s only UAV flyer with a confirmed air-to-air kill.

“How’d the first flight on the new model go?” asked Maj Helms. “Those new smart parts give you any trouble?”

“Hardly! In fact, they’re the reason you’ve got a four-ship flight and full coverage tonight. About two hours into the sortie, I got an ether message from Otto Auditor, the gate keeper of that BRAIN thing it told me we’re authorized to manufacture and install a new wing-form actuator circuit at Samsung’s expense. Funny thing is, it was just an info

copy to me, explaining how the bird itself, tail number 2025, had requested the new circuit, received contractor funding for the warranted part, scheduled the installation, and arranged for disposal of the old part.”

“Well Sloan, now I know why they limit our time on the console, because you’re not making any sense to me. I think you’ve been staring at the old CRT a little too long.”

“See for yourself, sir. Use the gloves after you authenticate and go virtual. Then grab the new bird.”

“Slow down Sue, you know I don’t like these virtual reality gloves.” Major Helms grudgingly pulled on the VR gloves and grumbled a terse human factors evaluation, “You can’t eat fried chicken with these things on.” With the gloves on, and his authentication complete, Major Helms furrowed his eyebrows and said, “All right, they’re on and I’m in. Who are all these people, Sue?”

“Well, they’re not really people, sir. They represent the systems our new bird’s been talking to. Spill the graphical history bucket and you can see everything that happened in about a one-minute animation. There, see how the smart part detected that the wing-form actuator circuit was out of spec and reconfigured the card to compensate?”

“Yeah, it’s supposed to, isn’t it Sue?”

“Sure, but look what happened next. The smart part tells Otto to come up with a replacement. Otto, the gatekeeper for the logistics system of systems they call BRAIN, then validates the smart part’s request and talks to Red E. Ness to establish our priority, Budge-It to see if there’s money, Man-Per to ensure we’ve got the people to change out the part, and Add-r-Quit Space to see if we’ve got the facilities to change the part. Meanwhile, Red talks to FAR-Ther and Done Deal, the acquisition and contracting

systems, and figures out the circuit is still under warranty. Not only that, but our priority is so high, Trans-Actor says we can make the part in the agile manufacturing unit (AMU) instead of dropping it in with tonight's delivery. So, Red has Samsung beam the manufacturing file to the AMU and the part is made in the field at their expense."

"Hey, where'd the old part go, Sue?"

"Sir, it dropped out of the bird and into Dispose-All, who arranges for repair, return, or disposal."

"Well all right Sue, so now machines have complete control?"

"Not completely sir, see that guy over there?"

"Yeah, who's he, another system represented by one of your people graphics? By the way Lt Sloan, I think your virtual reality icons are a little too . . ."

"User friendly sir? Their all within reg, but I can make them more user unfriendly if you like."

"Never mind, just tell me what system that old guy over there looking down on us represents."

"That's not a system sir. He represents the human analysts who oversee the system and work out conflicts the systems can't solve."

"Oh! Well, that seems like a good idea. I suppose you could have asked the analyst to work your *wing doufer* problem?"

"Not likely sir, Otto sent me the ether message summarizing everything that had happened twelve seconds after the smart part requested the new part. And he wasn't even sweating."

"Sweating?"

“Yes Sir, the Otto icon sweats if your task uses more than two tenths of a percent of total throughput . . .”

“OK Sloan, I get the picture. Now I want to fly jets. I’ve got a mission to do, you know.” Major Helms was settling into the console when he shook the sensor-cueing device and said, “I’ve got it.”

“Pardon me, sir?” Lieutenant Sloan wasn’t sure what the Major meant by that and she certainly wasn’t convinced he had a handle on all the features of the new bird, let alone the BRAIN it interacted with.

“Oh never mind, Sue. Hey, when’s all this new stuff gonna make our job any easier?”

“Consider it done sir!” she answered.

This scenario represents a problem that was completely solved through use of the automated features of BRAIN. Human intervention was not required in this instance; however, with a minor change to the scenario, we can demonstrate a “human” interface. In the revised scenario, the part is no longer under warranty and there are no funds available to fix or replace it. At that point, the analyst with logistics oversight responsibility for Lt Sloan’s organization would become involved and communicate with the “budgeteer” responsible for funding Lt Sloan’s equipment. If they determined that the requirement was sufficiently critical, they would “reprogram” funds to pay for it. The analyst would update the system and Budge-It would reflect the new funding.

Chapter 5

Recommendations

Despite the changed political, economic, and technical environments of 2025, the mission of providing logistics support for air and space forces remains constant. What *does* change in 2025 is the logistics process for providing that support. The process will be responsive, automated, and integrated. It will be so routine that it will not present a persistent worry to the CINC, who may be tasked with missions ranging from humanitarian relief to total war.

Whether the logistics mission of the future is service-specific, DOD general, or contracted out is irrelevant. Survival of the logistics process depends on taking advantage of the technologies discussed and on developing an automated system which provides instantaneous, automated, cross-talk capabilities among functions.

A System of Systems

The logistics system of systems—BRAIN—is fully automated. It seamlessly integrates all phases of the logistics process. It provides the operator total visibility of all assets from cradle (acquisition) to grave (disposal). Commanders can rest, assured that all platforms they require will perform. They will know that their equipment will be

supported by well-trained personnel who have the necessary parts, equipment, and facilities readily available. Improved reliability and interoperability of systems and their replacement parts will reduce downtime and requirements for routine maintenance.

Technologies

No longer will a requisition fall into the “black hole.” The excuse, “the part is on order with no specified delivery date” disappears. Smart parts will self-diagnose problems and automatically generate reorders. Smart parts, agile manufacturing, and a “just-in-time” partnership with industry will provide rapid resupply capability.

The foundations for the systems and processes described herein are being explored today. The BRAIN system relies heavily on advancements in the areas of artificial intelligence, connectivity of automated systems, and hardened communications capabilities. Many initiatives throughout government and private industry seek to improve these technologies.

Agile manufacturing techniques that use lasers and molecular materials are under development in military and commercial labs. The ability to manufacture “on the spot” provides an added dimension of flexibility and holds great promise for future employment. Virtual reality is another hot technological commodity. The potential uses for this capability are being explored on many planes. The amusement industry has embraced the concept and is providing creative games to stimulate the imagination of youngsters. The military is already providing virtual aircraft mock-ups to test aircraft designs.

Integration

While these technologies are critical to a successful logistics system in 2025, changing the attitudes within the communities that interface with the logistics community will be the essential “first step.”

A fully integrated logistics system will upset many rice bowls. Today’s functional stovepipes create a disjointed and counterproductive logistics process. The success of the logistics process depends upon a radical change in the way all disciplines adapt to sharing information and that they accept a different way of doing business. Strong, decisive leadership is required to break down functional barriers. However, once these barriers are destroyed, a new road leading to an enhanced logistics process must be paved.

Investment

The initial investment will be great, both in terms of changing the hierarchy and the cost of buying the hardware, software, and training to support the system. The payoff will be enormous in terms of reduced staffing, costs, and efforts to support the aerospace forces of 2025. The overall cost can be reduced by delaying implementation of a new system until after the required technologies have been proven in other areas. By waiting, we may be able to adapt commercially available systems to a military application. This must be weighed against the cost of lost opportunity.

Skills Mix

Skills requirements within the aerospace forces will shift substantially. The requirement for “hands on” contracting personnel is substantially reduced. Most pricing, bid solicitation, and analysis are performed electronically. Experienced acquisition professionals will still be required to solve problems the system cannot address. The increased use of computers, the need for complex software, problems arising from system integration, and a greater need for computer security may result in a shift from traditional logistics disciplines to personnel with skills in the areas of computers, operations analysis, and communications security. Additionally, staffing levels for materiel management will allow one person to manage many more items than they can currently manage.

Conclusion

In conclusion, we must develop a computerized system that is fully responsive to commander needs. We must capitalize on the emerging technologies. We must integrate all functions in the logistics chain. A commander may have all of the newest technology to accomplish any mission in the future; however, without an automated, fully integrated logistics support system, he may be limited by the same challenges he faces today. The expense of implementation can be minimized by procuring technologies developed by industry.

By integrating the system we have described with the new weapons and aircraft that will be available in 2025, the Commander will *always* be able to report to the President, “Consider it done!”

Appendix A

Lift Platform Concepts

Additional lift platforms could be acquired through the development of a low-cost, lighter-than-air craft or a modular, multimission aircraft. As an extension of earlier LTA accomplishments (such as the US-built dirigible *Akron*, launched in 1931 with a gross lifting power of over 200 tons), a modern LTA craft could be designed. It would use lighter but stronger materials and miniaturized equipment to significantly reduce the empty weight of the craft and achieve useful lift capabilities of 100 tons.¹ Additionally, the lower cost of the LTA craft, loosely estimated to be one-twelfth the cost of modern cargo aircraft, would allow for larger numbers of these craft to be acquired for the same cost.²

Similarly, the modular medium-lift aircraft concept calls for a multimission-capable, high-aspect-ratio, flying-wing aircraft. The aircraft would serve as an airlifter, tanker, or strike platform, as needed, depending on the type of load module installed. Load modules would be completely intermodal, thus ensuring compatibility with other transportation platforms. Potentially, the multimission-capable aircraft could allow for an increase in the

number of aircraft apportioned to airlift and refueling during the lodgment and redeployment phases of a campaign.

Increased transport payloads could be possible through use of wing, in-ground-effect (WIGE) technology (fig. A-1).³

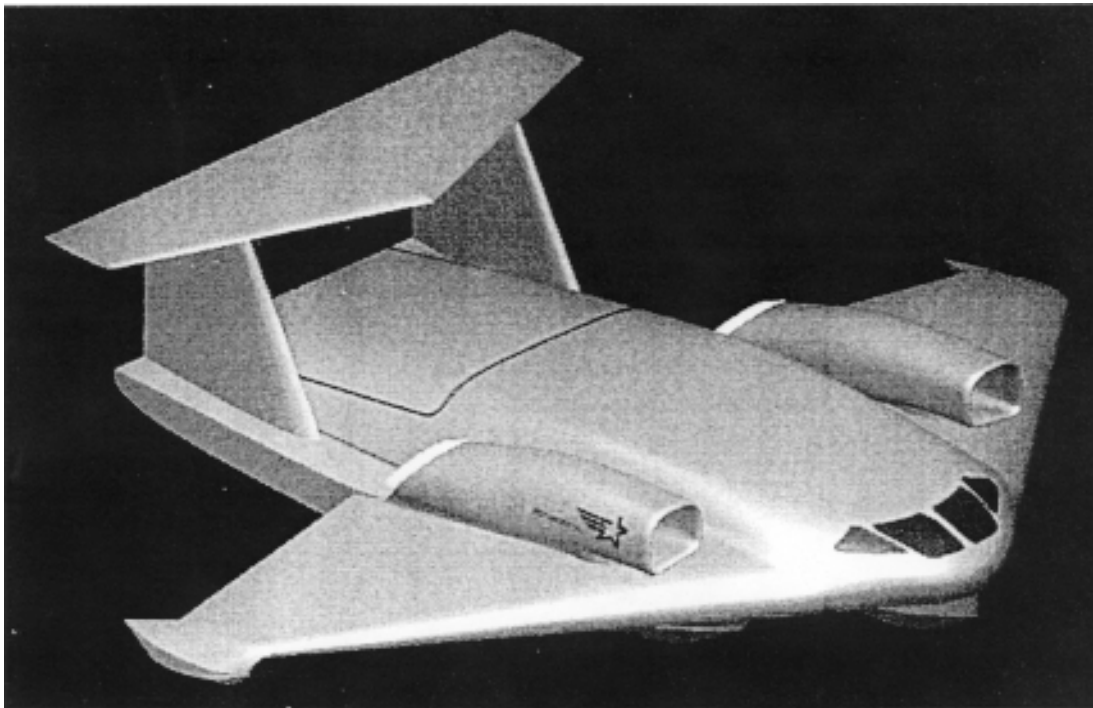


Figure A-1. Conceptual Wing in-Ground-Effect Aircraft⁴

The largest known WIGE aircraft was produced by Russia's Central Hydrofoil Design Bureau and is a 400-to-500 metric-ton (881,600-1.1-million-pound) aircraft.⁵ Advancements in materials and engine efficiencies could allow extremely large payloads. With near-real-time meteorological and sea-state data, these heavy-lift platforms could skim the ocean's surface at very low altitudes and circumnavigate adverse weather conditions.

Concepts capable of enabling faster equipment transport include super-efficient aircraft engines built from advanced materials using endothermic fuels and sophisticated, intermodal, standoff cargo containers. These advanced engines could provide a 100-percent increase in thrust-to-weight ratio and a 50-percent reduction in fuel consumption.⁶ Increasing the thrust and fuel efficiency of aircraft engines would allow greater cargo loads and reduce the need for enroute refueling. Additionally, sophisticated, intermodal, standoff cargo containers could eliminate the need for transportation aircraft to land and unload their cargo. Future containers would be air-dropped—and smart enough to navigate to a precise location on the ground. Additionally, they would be capable of limited self-propelled ground movement, and self-loading on other transportation systems. Their contents could be determined by plugging an information scanner into the container's data port or by initiating a holographic image display. By eliminating the need to land the aircraft for unloading at its destination and reducing the equipment required to handle the containers during aircraft loading and on the ground, delivery time and costs could be reduced.

Notes

¹ Lt Col Donald E. Ryan, *The Airship's Potential for Intertheater and Intratheater Airlift*, (Maxwell AFB, Ala.: Air University Press, June 1993), 6.

² Ibid.

³ 2025 Concept, no. 900499, "Large Cargo Hauling Wing-In-Ground-Effect (WIGE) Vehicles," 2025 Concepts Database (Maxwell AFB, Ala.: Air War College/2025, 1996).

⁴ USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century* (unpublished draft, the materials volume, 15 December 1995), 24.

⁵ Jeffrey M. Lenorvitz, "ARPA Team To Visit Russia For WIG Vehicle Study," *Aviation Week & Space Technology*, (24 May 1993), 25.

⁶ *New World Vistas*, (unpublished draft, the materials volume), viii.

Bibliography

- Air Force Scientific Advisory Board, briefing/interview with 2025 Logistics Thinking Team, Maxwell AFB, Ala., 7 February 96.
- “Application of Artificial Neural Network (ANN) to Aircraft Diagnostics,” AL/HRGO home page, World Wide Web; Internet.
- Bertram Creme, Armstrong Laboratory, Logistics Research Division, Wright-Patterson AFB, Oh. “S&T Issue: Visualization Technology For Logistics,” (excerpts from published works), February 1996.
- Brandt, Craig M. (Dr.) et al. “Logistics 2025, Changing Environments, Technologies, and Processes.” (unpublished work), Air Force Institute of Technology, Wright-Patterson AFB, Ohio, 1996.
- Cohen, I.K. and R. A. Eden. “Lean Logistics: A More Responsive Robust and Affordable System”, *RAND DRR 630-AF*, January 1994.
- EOS Technologies, Inc, for the Army Space Institute, 1990 “Space Support in Mid-Intensity Conflict,” edited by Maj Pat Battles: Air Command and Staff College, Maxwell AFB, Ala., in *Theater Air Campaign Studies*, (1995): 306.
- “Food For Space Flight,” in NASA Facts, (NASA home page), (cited 15 March 1996); <http://shuttle.nasa.gov/sts-69/factshts/food/html>; Internet.
- James C. Rainey (Lt Col), interview by Logistics Thinking Team, Air Force Logistics Management Agency, 14 February 1996.
- Jeffrey M. Lenorvitz. “ARPA Team To Visit Russia For WIG Vehicle Study,” *Aviation Week & Space Technology* (24 May 1993).
- Joint Publication (JP) 4-0, *Logistics*. The Pentagon, Washington, D.C.: 1995.
- Kelley, Jay W. (Lieutenant General, USAF). “Brilliant Warrior.” (unpublished work), Air University, Maxwell AFB, Ala., 1996.
- Lou Johnson (Lt Col), Armstrong Laboratory, Wright-Patterson AFB, Ohio, staff presentation document, 14 March 1996.
- McGuiness, Kevin. “NANOPLASTICS - How ‘Intelligent’ Materials May Change Our Homes” *The Futurist* (January-February 1995): 50.
- Miller, Gregory (Lt Col) et al, “The Virtual Integrated Planning and Execution System: The High Ground of 2025.” Project 2025 White Paper, Air University, Maxwell AFB, Ala., March 1996.
- Negroponte, Nicholas. *Being Digital*. New York: Vintage Books, 1996.

- News From AFAR*, vol. 1, no. 3 (June 1995 special), 1.
- "Readiness Base Spraying Assessment," <http://www.nslc.fmso.navy.mil/rbs1.htm>; Internet.
- Ryan, Donald E. (Lt Col). *The Airship's Potential for Intertheater and Intratheater Airlift*. Maxwell AFB, Ala.: Air University Press, June 1993.
- Staff writer. "Cargo 54, Where Are You ?" *The Economist* (1995): 73-74.
- Staff writer. "A Robot Wings It" *Mechanical Engineering* (April 1995): 3.
- Toffler, Alvin, and Heidi Toffler, *War and Anti-War*. New York: Warner Books, Inc., 1995.
- USAF Scientific Advisory Board. *New World Vistas: Air and Space Power for the 21st Century*. Unpublished draft, the Materials Volume. 15 December 1995.
- . *New World Vistas: Air and Space Power for the 21st Century*. Unpublished draft, the Space Technology Volume. 15 December 1995.
- Van House, Michael R. (Lt Col). "A Proposal to Restructure the Logistics Group." *Air Force Journal of Logistics* (Summer 1995): 32.
- The Wall Street Journal*, 20 March, 1996.
- 2025 Concept, no. 200019, "Smart Packages," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 200038, "Super-Airship Military Transports," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 200076, "Very Large, Heavy Lift Transports," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 200225, "Spaced Based Manufacturing and Recycling System," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 900233, "The very small, very smart bomb," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 900265, "Space Storage Modules To Establish Space-sourced Air Drop Capability," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 900380, "Modular Aircraft," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 900401, "Undersea Prepositioned Material," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 900499, "Large Cargo Hauling Wing-In-Ground-Effect (WIGE) Vehicles," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 900510, "Micro MREs," 2025 concepts database. Maxwell AFB, Ala.: 1996.
- 2025 Concept, no. 900539, "Aerospace Ground Equipment (AGE) Redesign," 2025 concepts database. Maxwell AFB, Ala.: 1996.

2025 Concept, no. 900672, "Integrated Logistical Sustainment," 2025 concepts database.
Maxwell AFB, Ala.: 1996.

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